

# Recent results on $J/\psi$ from NA50

NA50 Collaboration

P. Bordalo – LIP-Lisbon



<http://www.lip.pt/~paula/talkqm01.ps>

*Stony Brook, January 15-20, 2001*

# NA50 COLLABORATION

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# Outline

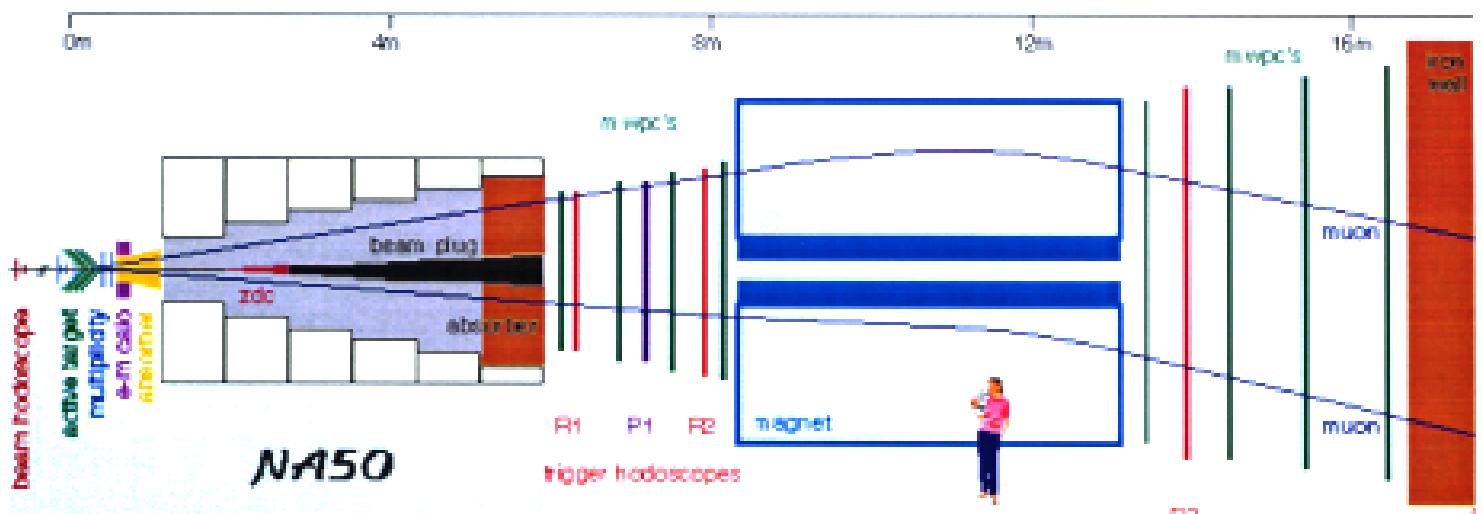
## *J/ψ* Production:

- $J/\psi/DY$  as a function of  $E_T$ ,  $L$  and  $\epsilon$
- New proton data
- Minimum Bias analysis
- ZDC analysis
- Comparision with models

## *J/ψ* Transverse distributions:

- $dN/dM_T$  distributions
- $\langle p_T \rangle$  and  $\langle p_T^2 \rangle$  as a function of  $E_T$  and  $L$
- Inverse slope parameter  $T$
- $dN/dp_T$  ratios for different centralities

# Experimental Setup



The  $J/\psi$  is detected via its decay into muon pairs

- Dimuon spectrometer:

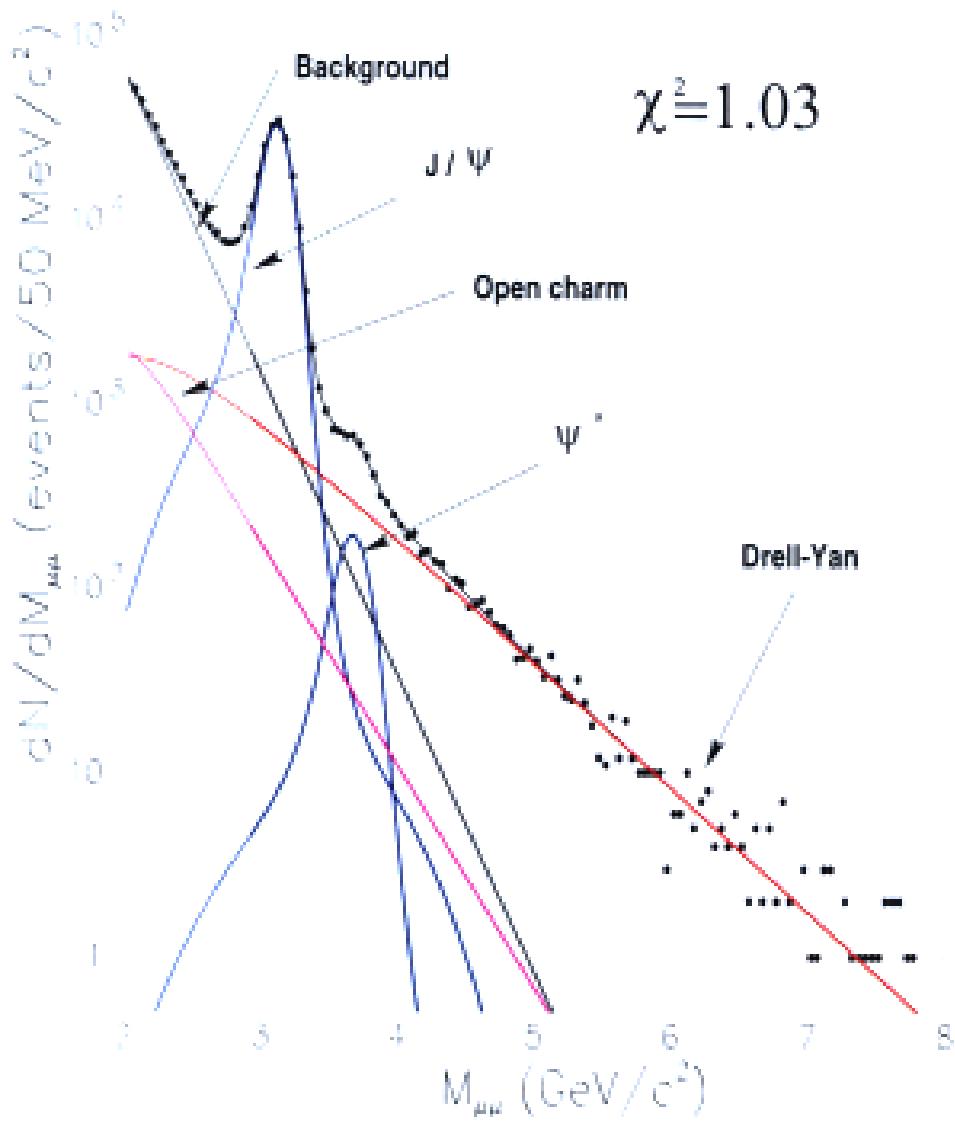
$$0 < y_{CM} < 1 \quad (2.92 < y_{Lab} < 3.92) \quad |\cos \theta_{CS}| < 0.5$$

	$J/\psi$	13.5%
Acceptance	DY(2.9 – 4.5)	15.1%
	DY (2.9 – 8.0)	15.4%

- Active target: Čerenkov counter blades
- Centrality detectors:
  - ▷ E.m. calorimeter ( $1.1 < \eta_{Lab} < 2.3$ )
  - ▷ Zero Degree Calorimeter ( $\eta_{Lab} > 6.3$ )
  - ▷ Multiplicity detector ( $1.5 < \eta_{Lab} < 3.5$ )

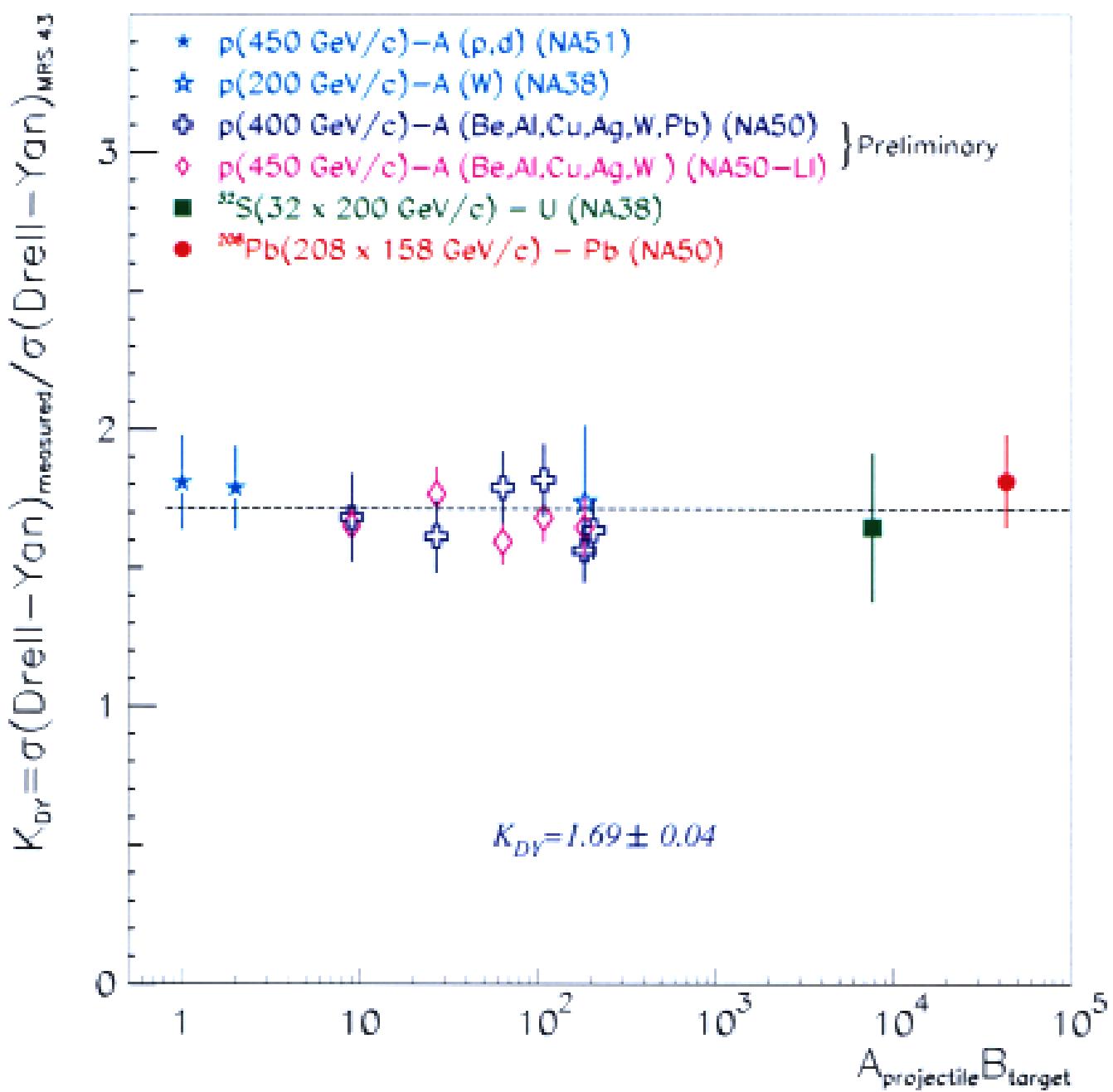
## Fit to the mass spectrum

$$\frac{dN}{dM} = A_{J/\psi} \frac{dN_{J/\psi}}{dM} + A_{\psi'} \frac{dN_{\psi'}}{dM} + A_{DY} \frac{dN_{DY}}{dM} + \frac{dN_{D\bar{D}}}{dM} + \frac{dN_{BG}}{dM}$$



- Combinatorial background, due to  $\pi$  and  $K$  decays, is estimated from like-sign pairs:  $N_{BG} = 2\sqrt{N^{++}N^{--}}$
- $J/\psi$ ,  $\psi^*$ ,  $D\bar{D}$  and Drell-Yan shapes from simulation and reconstructed chain

# Drell-Yan: Experimental K factor



Drell-Yan is proportional to the number of collisions  $A \cdot B$ , that is, it scales as expected:

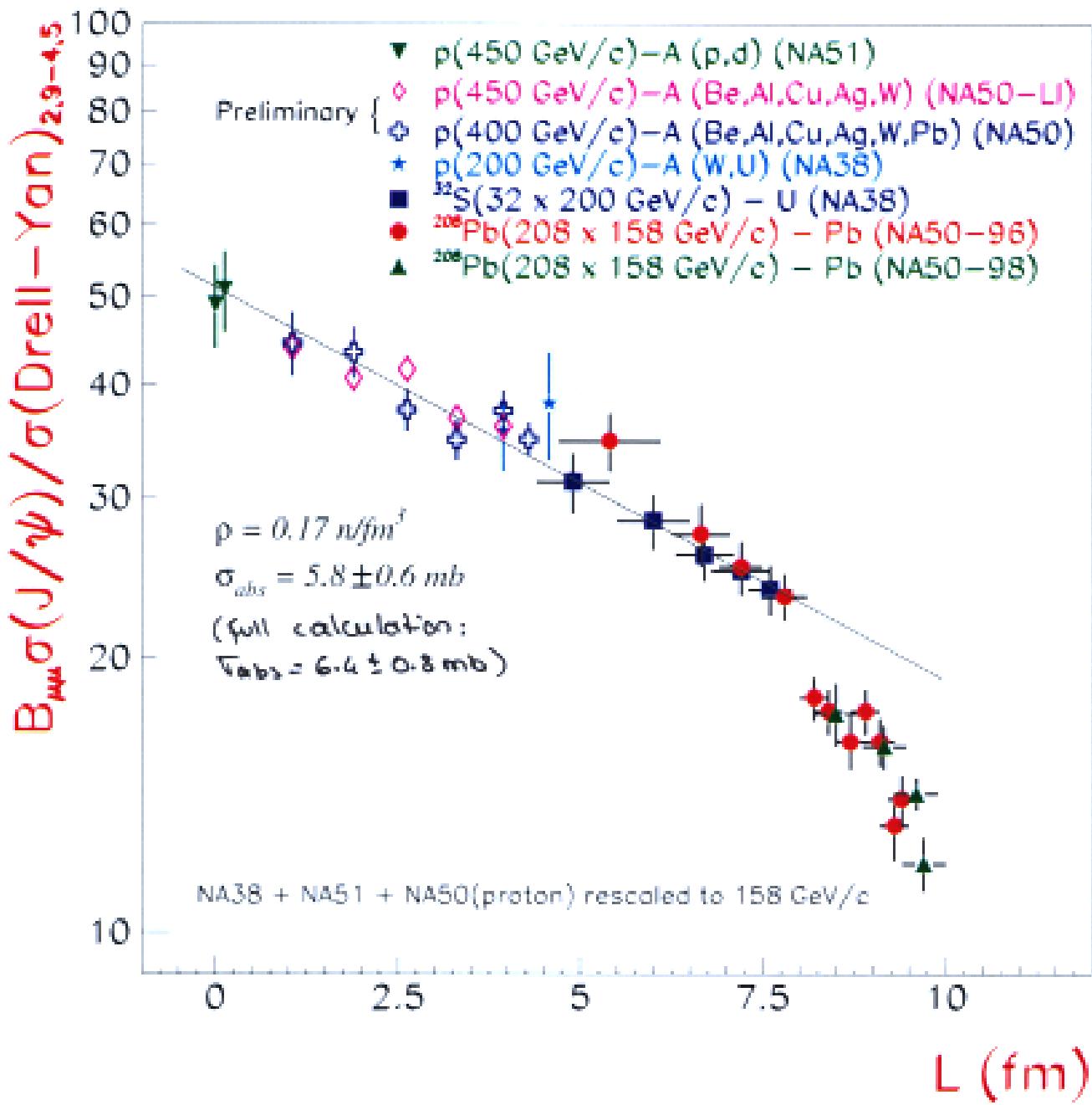
$$\sigma^{DY} \propto (A \cdot B)^\alpha \quad \text{with} \quad \alpha = 1$$

Previous K factor (excluding new proton data):

$$K_{DY} = 1.78 \pm 0.08$$

# $\psi/DY$ as a function of L

L - path length of the pre-resonant  $c\bar{c}g$  state in nuclear matter

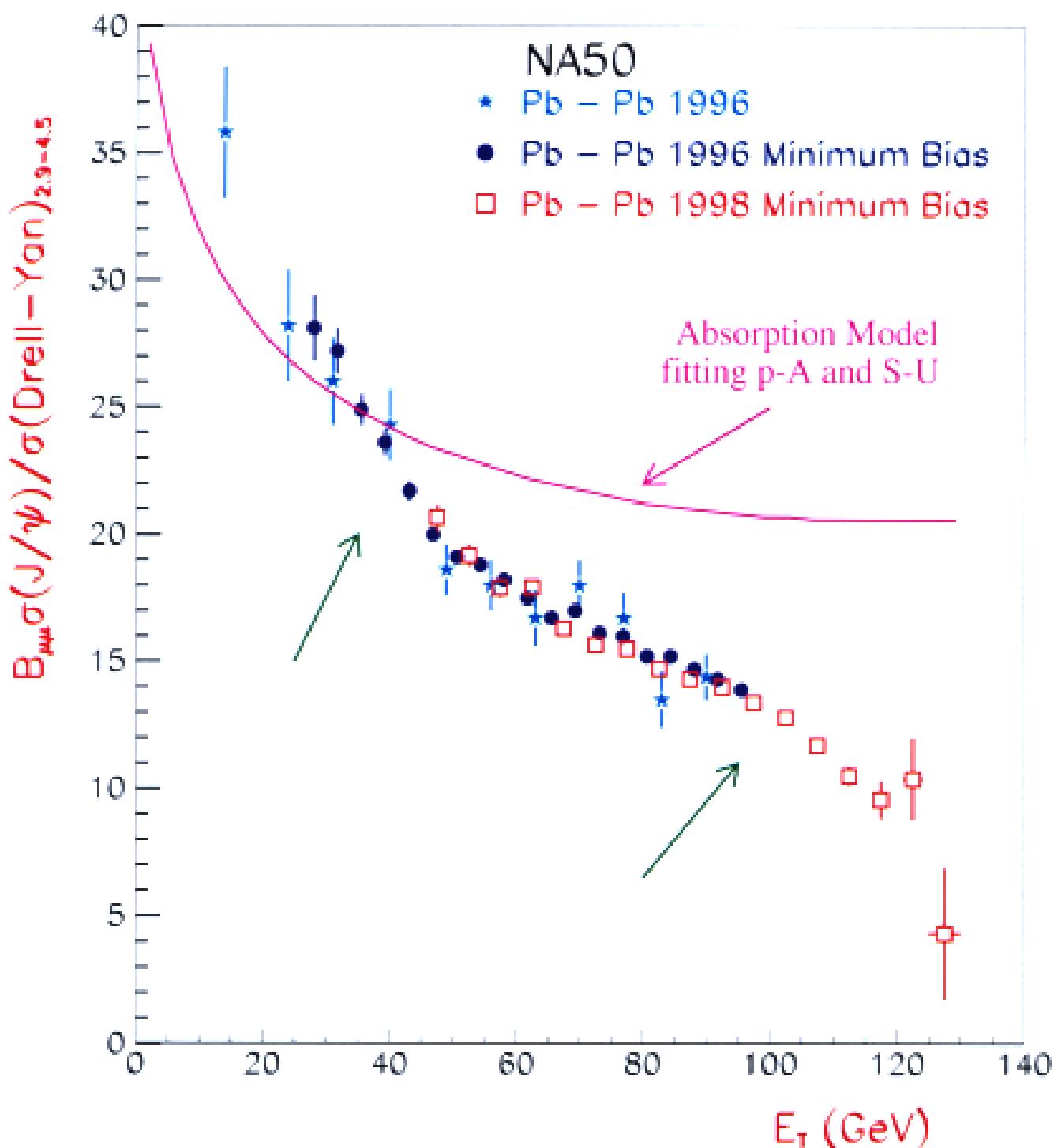


Fit including new proton data:

$$\frac{B_{\mu\mu}\sigma^\psi}{\sigma^{DY}} \propto e^{-\rho L \sigma_{abs}} \Rightarrow \sigma_{abs} = 5.4 \pm 0.4 \text{ mb}$$

Sudden 20% drop at L = 8 fm

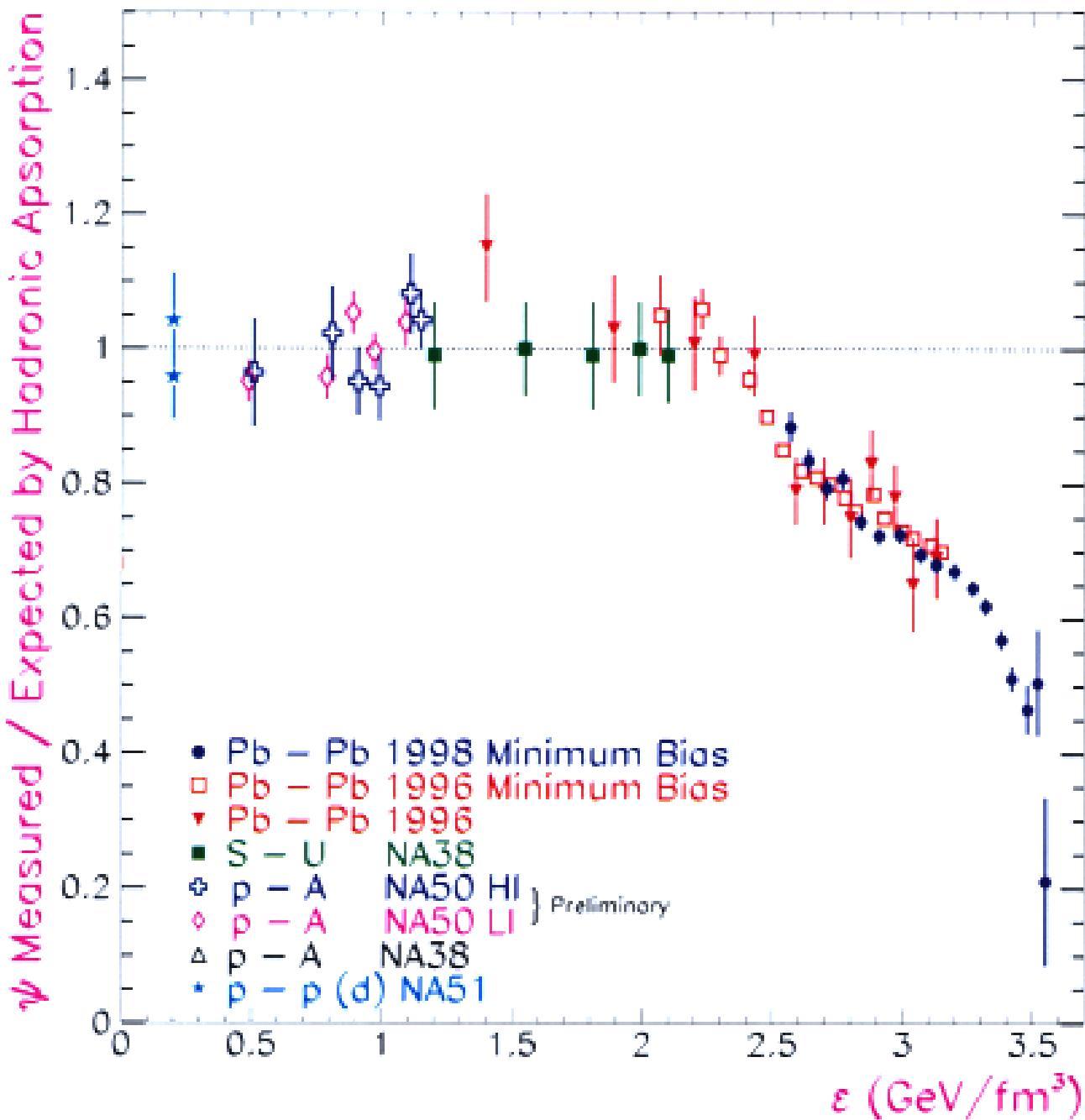
# $\psi/DY$ as a function of $E_T$



Solid line: exponential parametrization as obtained from fit to light systems (NA38 + NA51)

20% drop at 40 GeV and an inflexion point at 90 GeV followed by a steady steep decrease

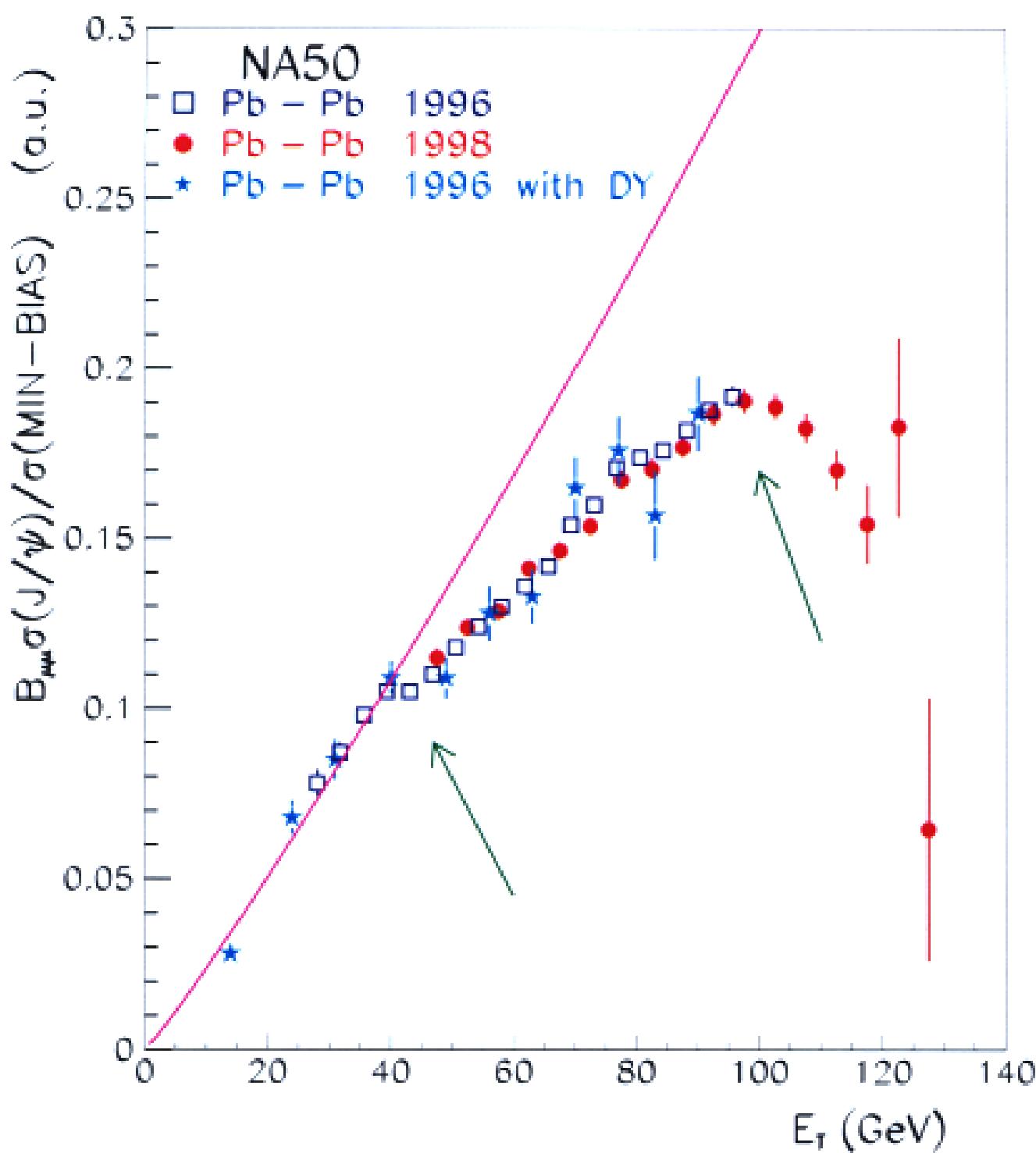
# $\psi$ Measured/Expected as a function of $\epsilon$



Expected: Absorption Model as obtained from fit to light systems (p-A and S-U)

Stepwise Pattern: 2 threshold values for  $J/\psi$  suppression,  $\simeq 2.4$  and  $\simeq 3.2$   $\text{GeV}/\text{fm}^3$

## $\psi/\text{Minimum Bias}$ as a function of $E_T$

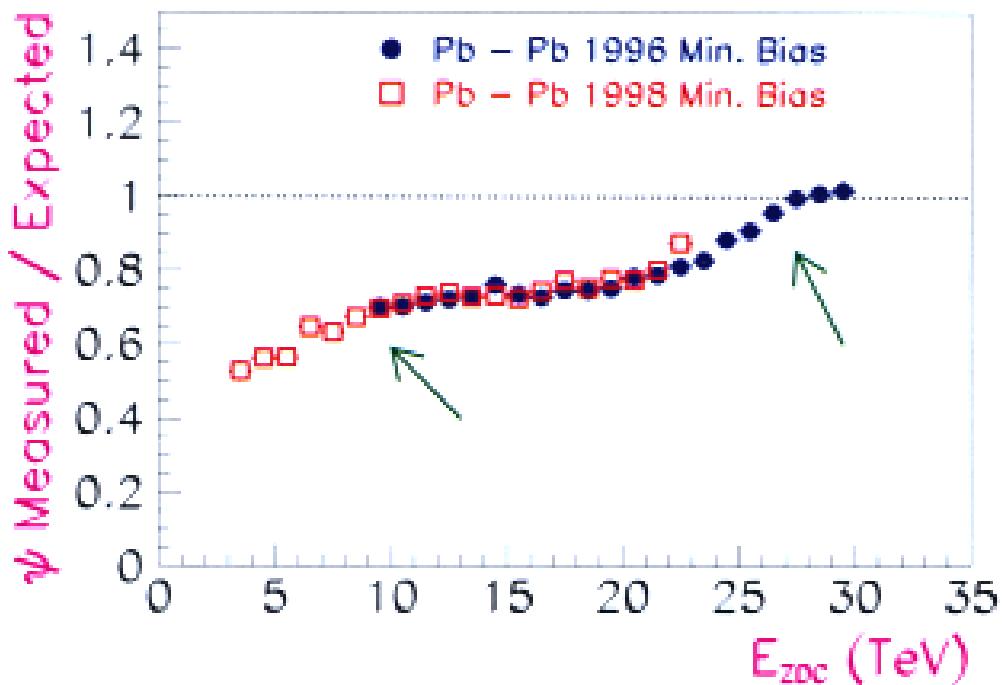
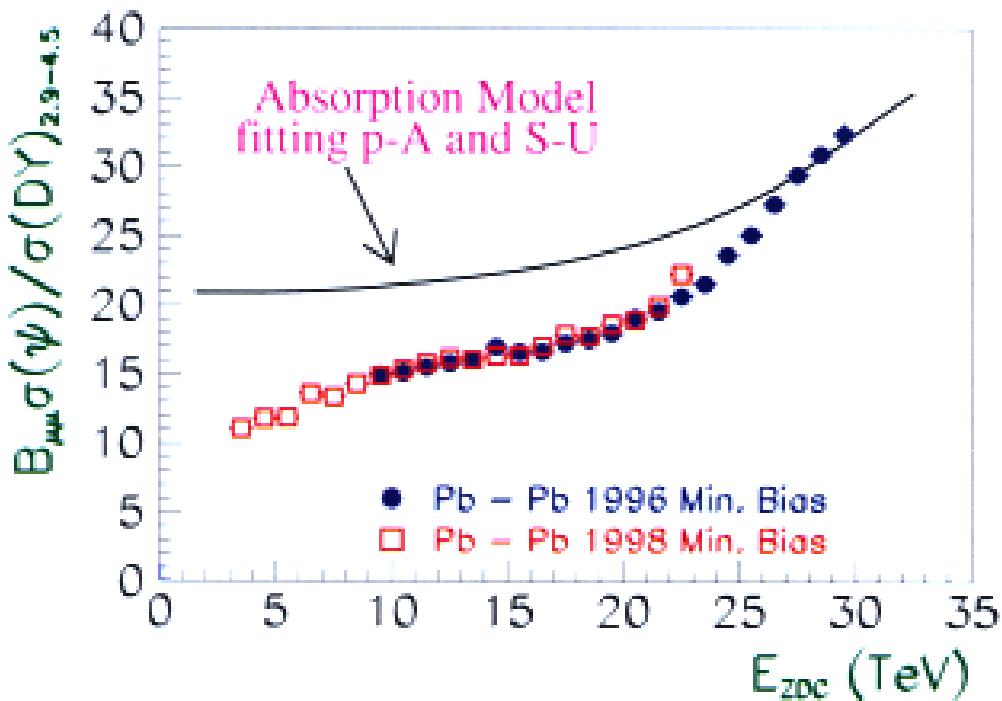


Solid line: Absorption Model with  $\sigma_{abs} = 6.4 \pm 0.8 \text{ mb}$   
as obtained from fit to p-A and S-U data (NA38 +  
NA51) with full calculation

Pattern exhibits 2 "accidents"

## $\psi/DY$ as a function of ZDC

Using another detector: ZDC, for centrality  $\psi$  studies

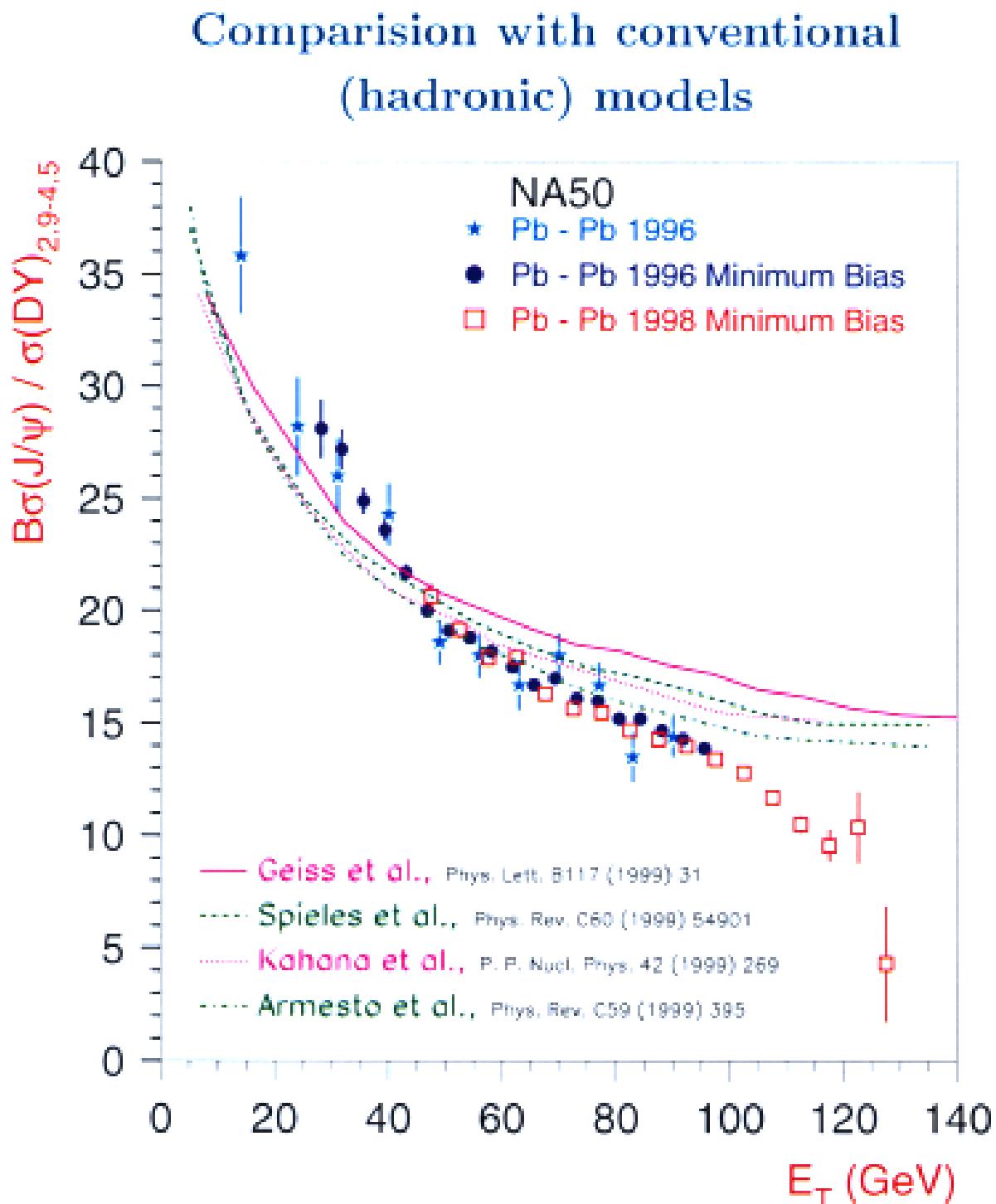


Solid line and Expected: Absorption Model as obtained from fit to light systems (p-A and S-U)

Observation of the 2 discontinuities in  $\psi$  suppression

## $\psi/DY$ as a function of $E_T$

Comparison with conventional hadronic models

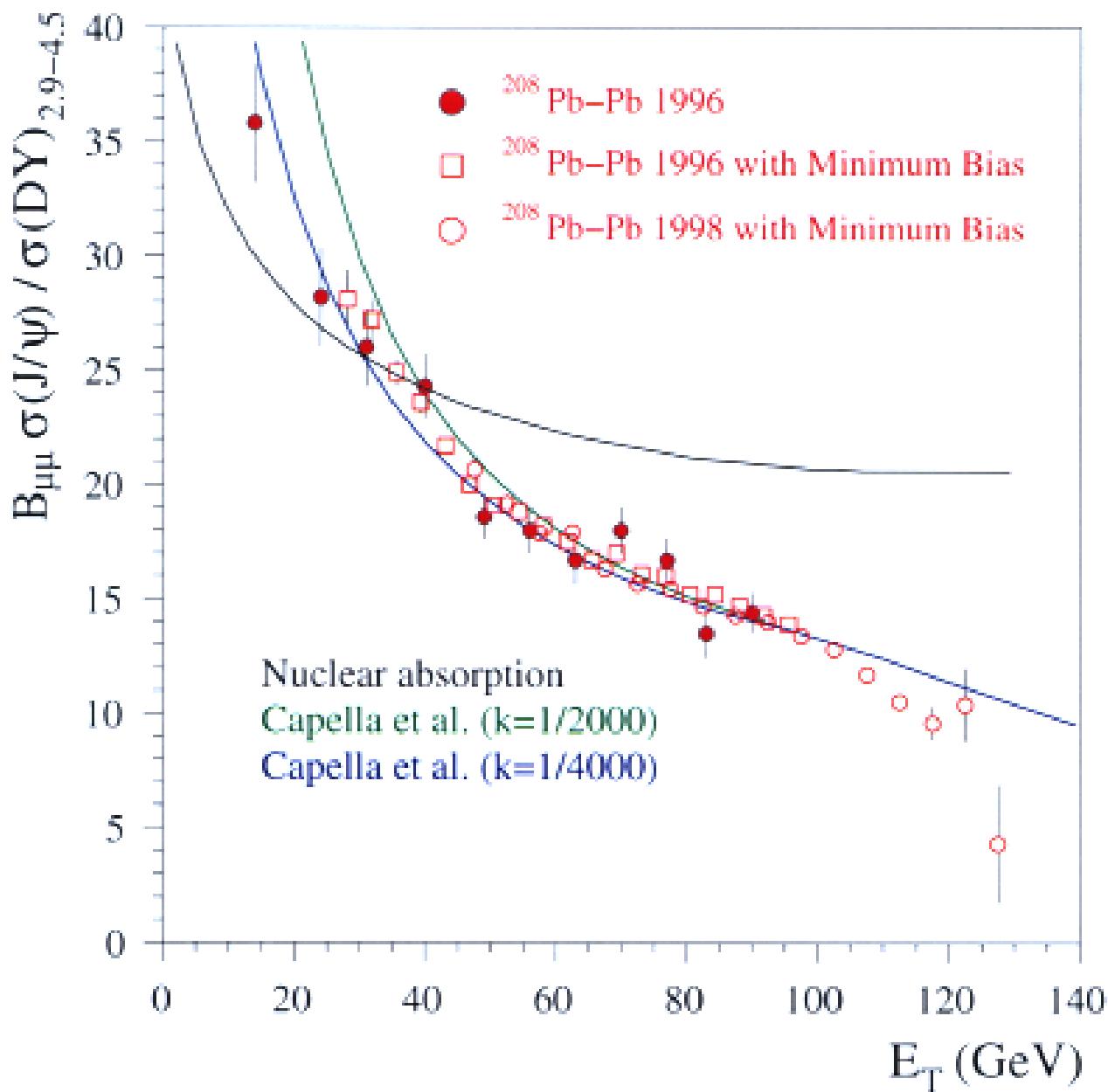


The stepwise suppression pattern rules out any of these conventional models

## $\psi/DY$ as a function of $E_T$

### Comparision with modified Capella's hadronic model ( $E_T$ fluctuations included)

(Phys. Rev. Lett. 85 (2000) 2080)



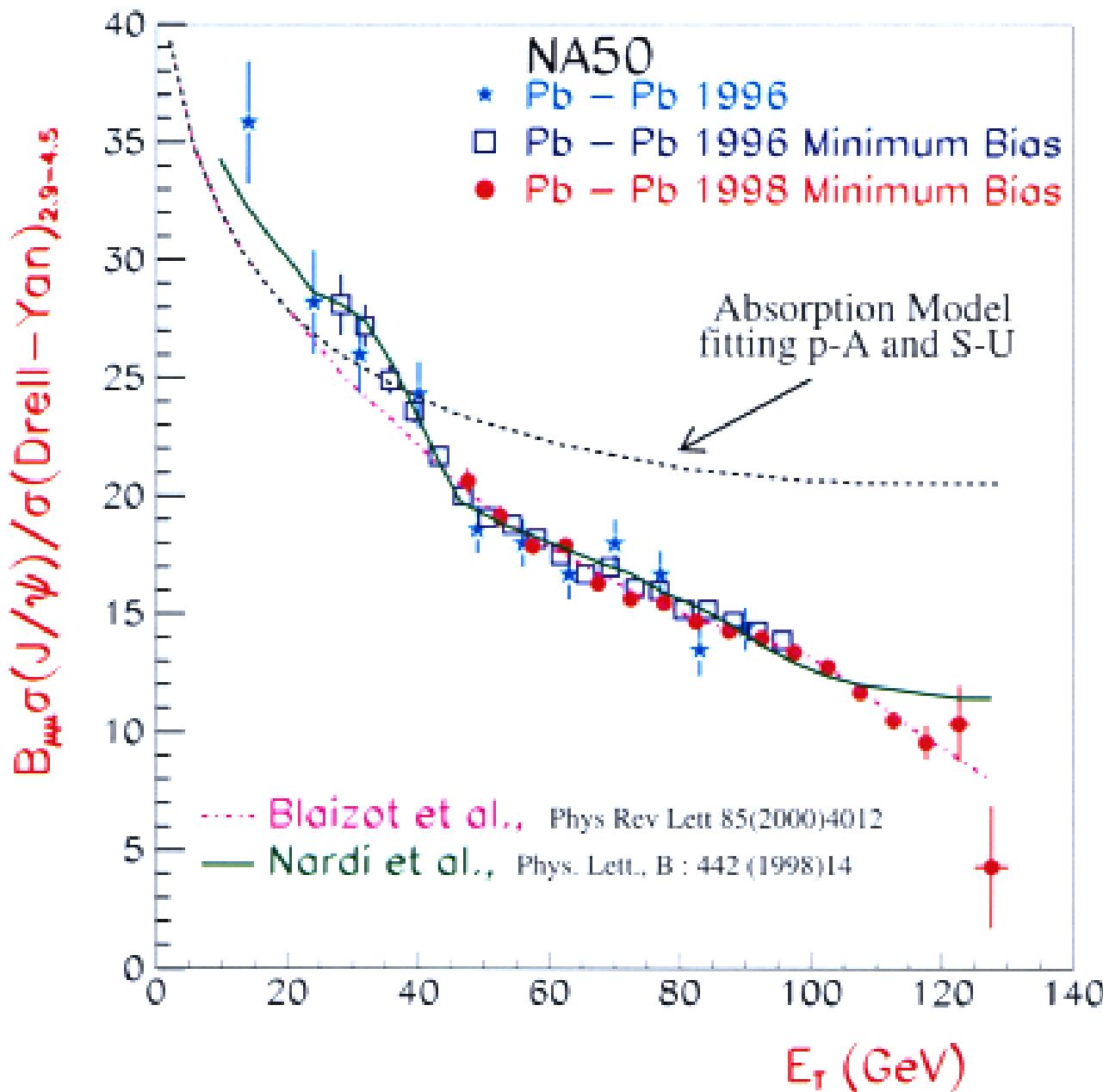
The model does not describe:

- ▷ the normal absorption as observed in p-A and S-U interactions (black line)
- ▷ the steady decrease for central Pb-Pb collisions

## $\psi/\text{DY}$ as a function of $E_T$

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### Comparision with models assuming QGP

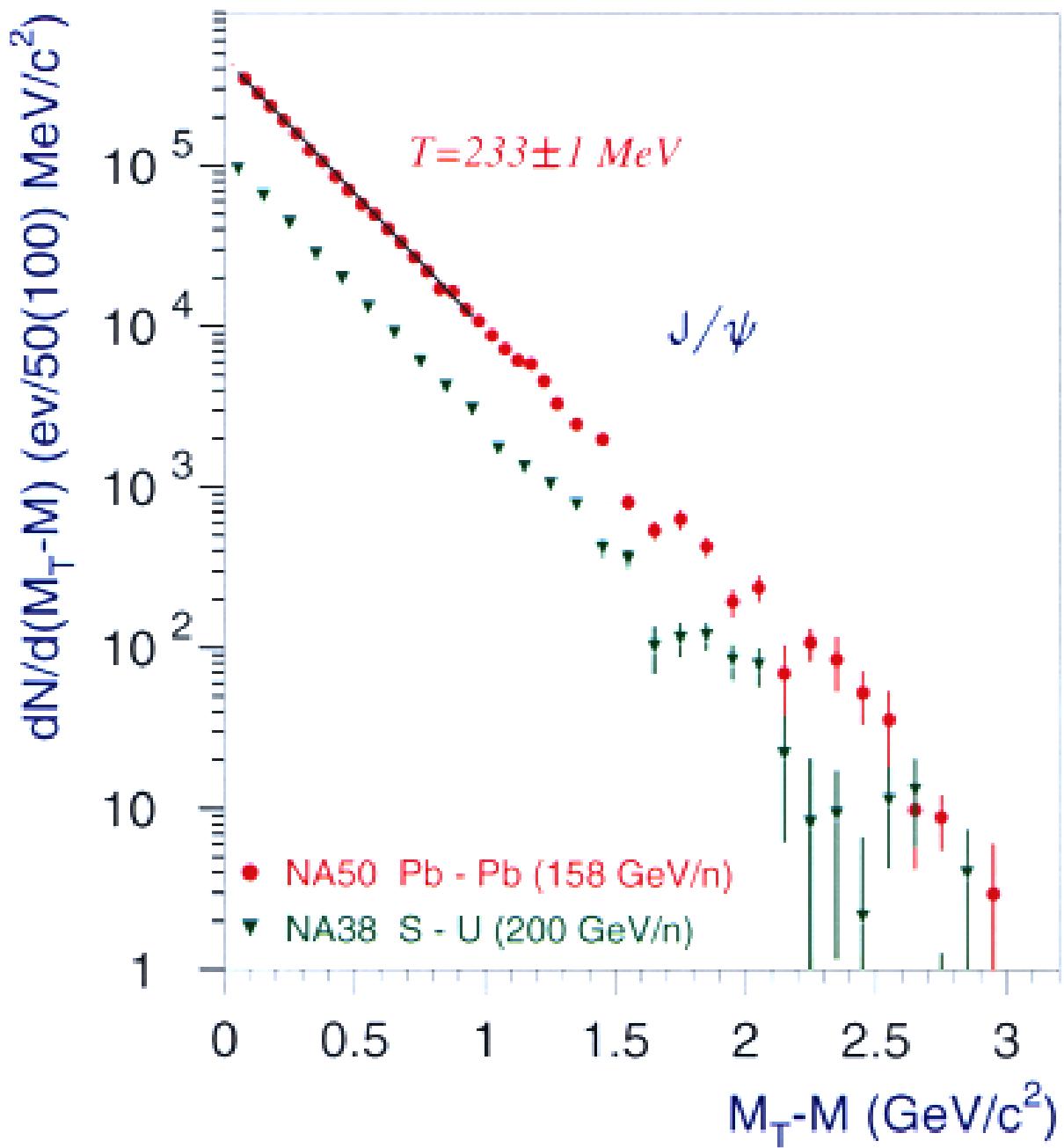


Magenta line: with gradual  $J/\psi$  suppression and  $E_T$  fluctuations

Green line: with two thresholds, corresponding to the  $\chi$  and the  $J/\psi$  melting points, but no  $E_T$  fluctuations

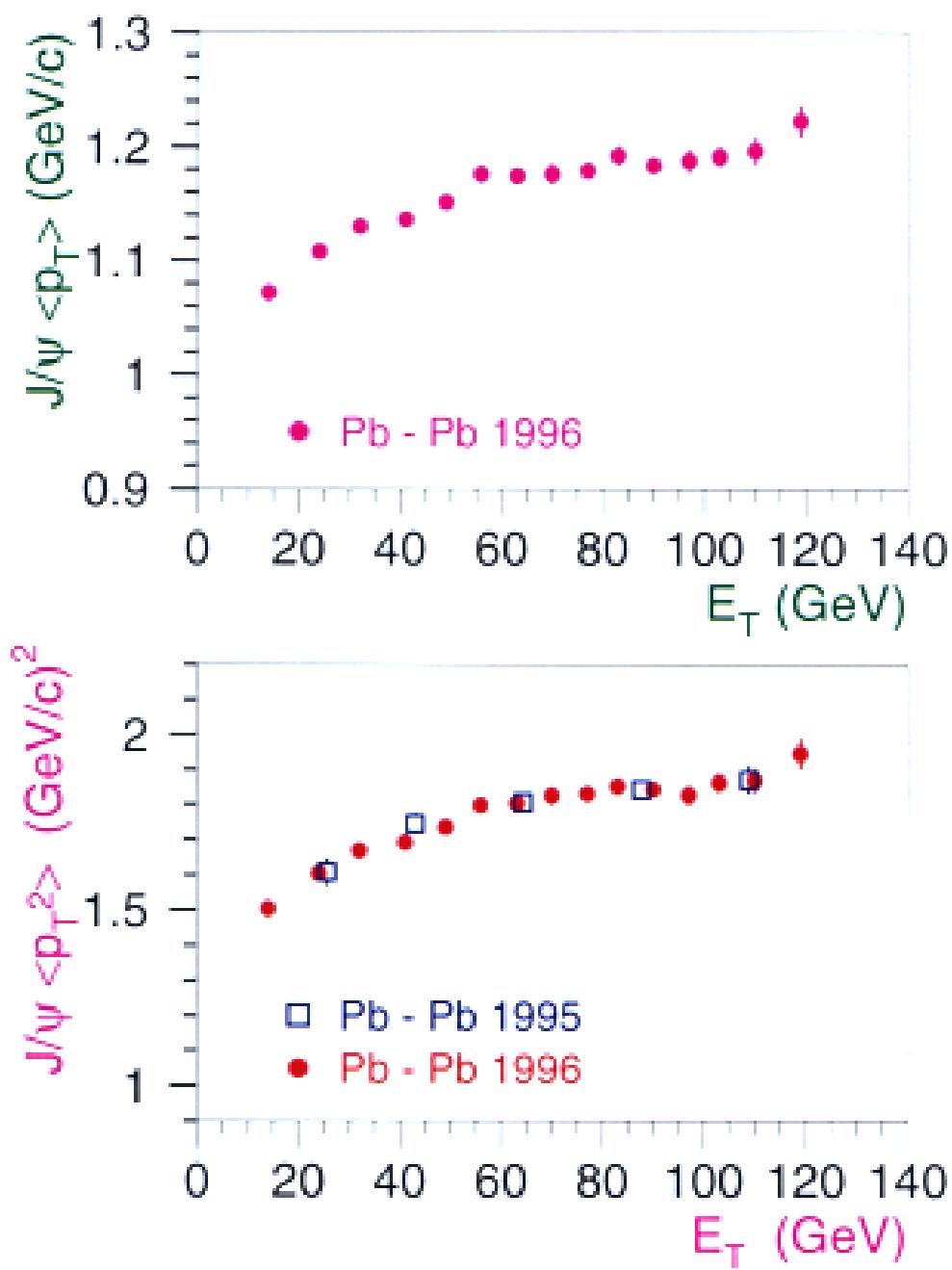
Quark and Gluon Deconfinement  
with 2 melting points plus  $E_T$  fluctuations  
seem necessary to describe the data

# $\psi$ Transverse Mass Distribution



Solid line: Fit with modified Bessel Function gives an inverse slope parameter  $T = 233 \pm 1 \text{ MeV}$  for Pb-Pb collisions at 158 GeV/nucleon

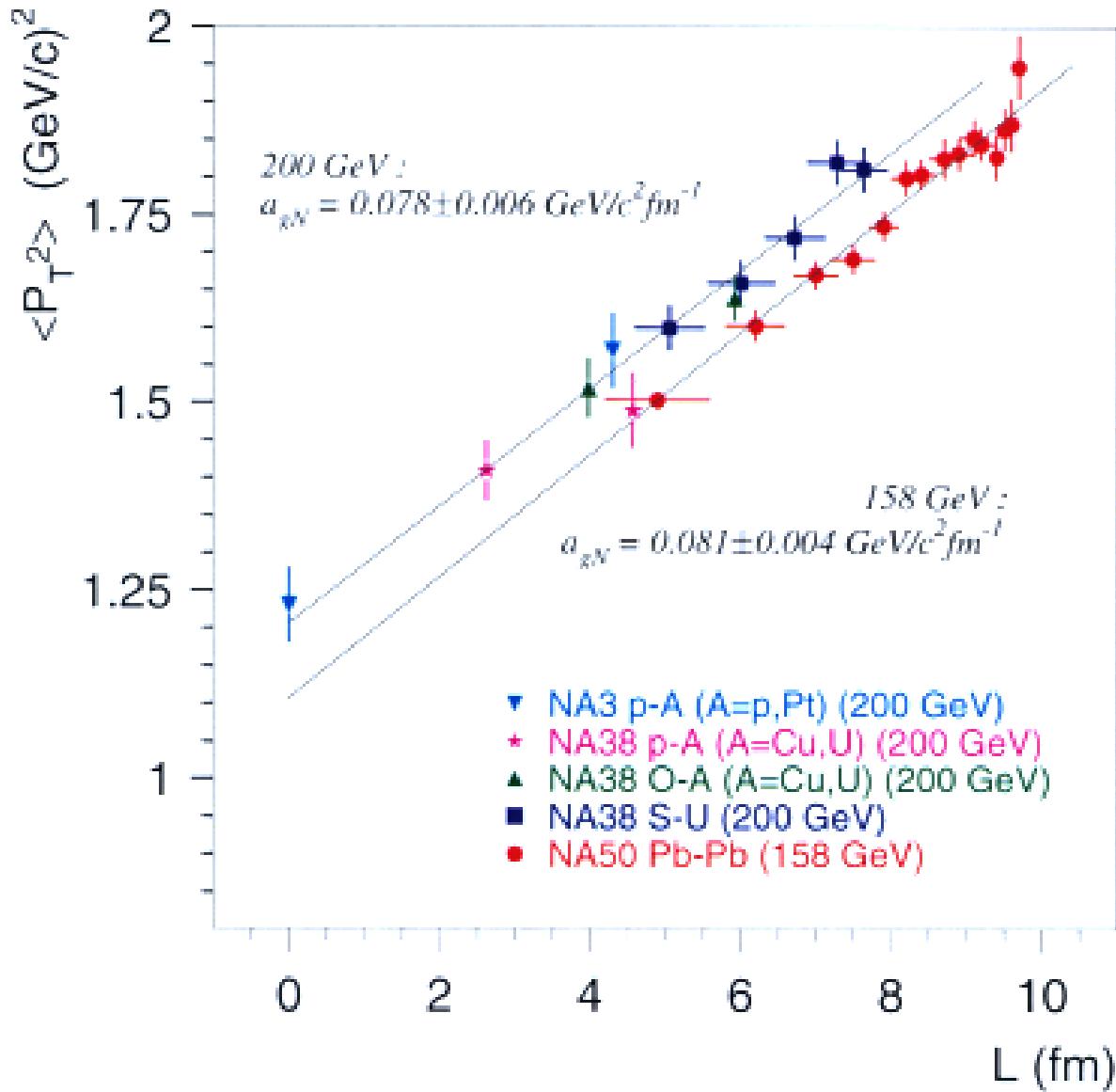
## $\langle p_T \rangle_\psi$ and $\langle p_T^2 \rangle_\psi$ as a function of $E_T$



Both  $\langle p_T \rangle$  and  $\langle p_T^2 \rangle$  show an increase followed by a saturation

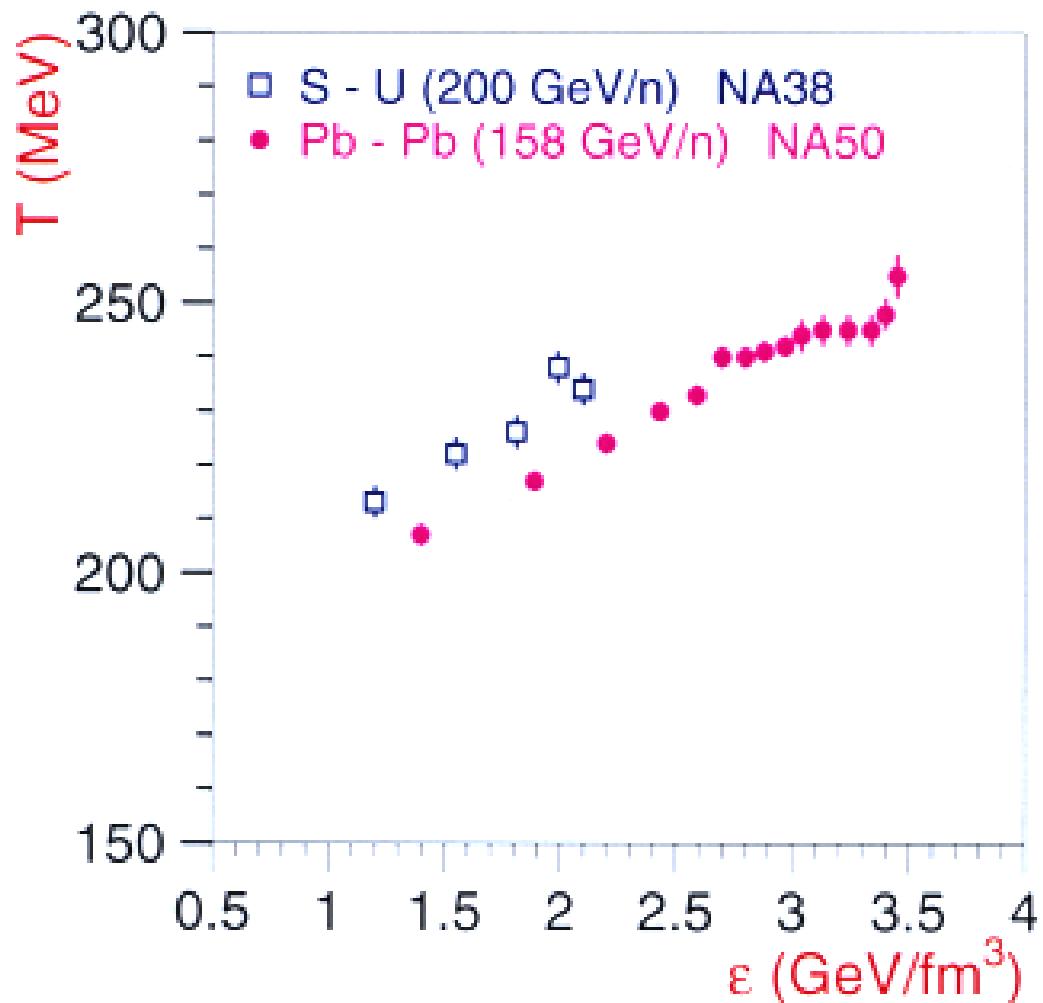
## $\langle p_T^2 \rangle_\psi$ as a function of $L$

Study of the initial state interactions effect:  $\langle p_T^2 \rangle$  as a function of  $L$ , the geometric length of matter crossed by the  $c\bar{c}$  state



- Fits according to:  $\langle p_T^2 \rangle(E_T) = \langle p_T^2 \rangle_{pp} + a_{gN} L(E_T)$  give compatible slopes for proton, Sulfur and Lead induced reactions. Fit with common slope:  $a_{gN} = 0.080 \pm 0.003 \text{ GeV}^2/c^2 \text{ fm}^{-1}$  with  $\chi^2/ndf = 0.65$
- $\langle p_T^2 \rangle$  depends on the beam energy

## $T_\psi$ as a function of $\epsilon$

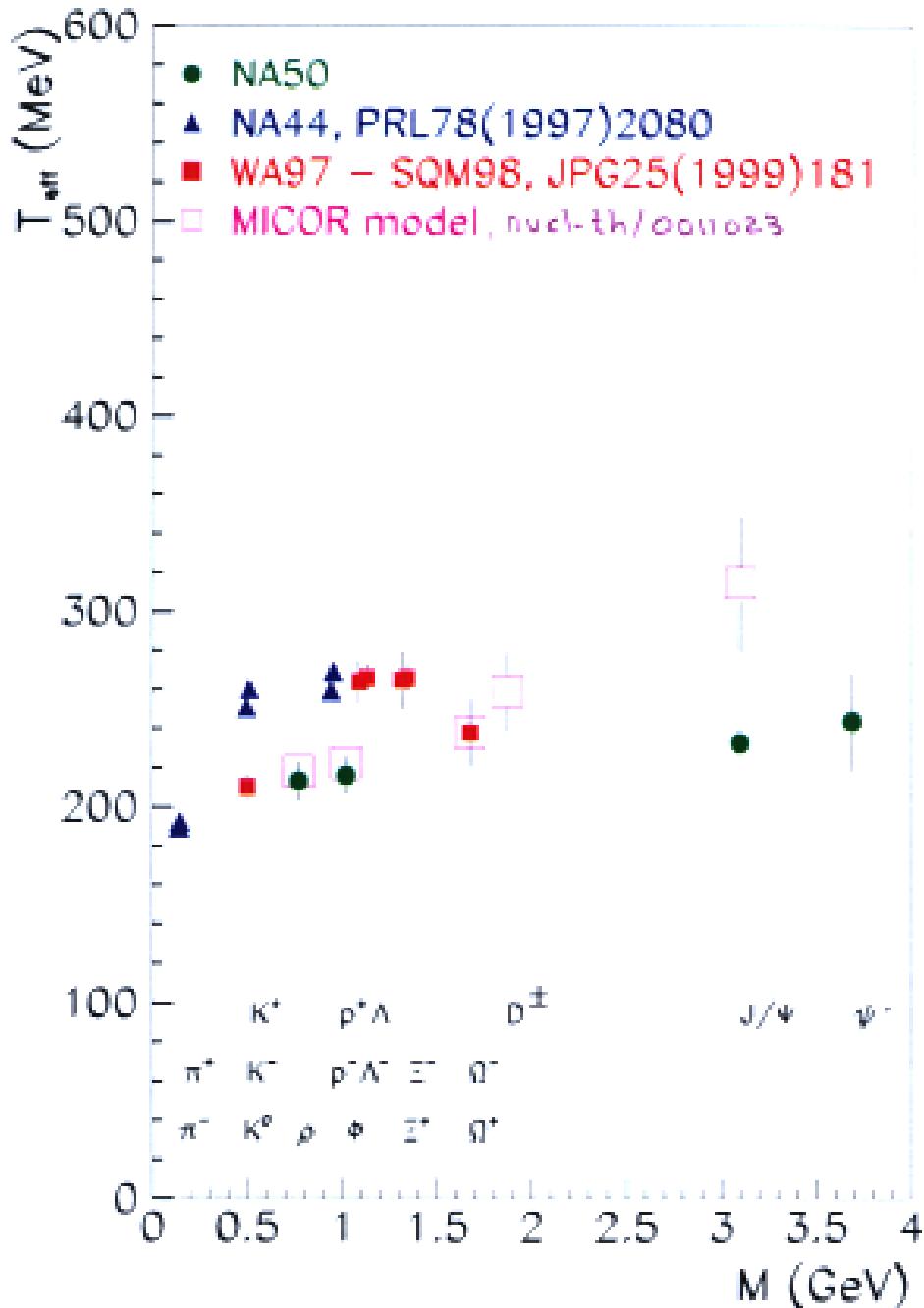


The inverse slope parameter  $T$  for Pb-Pb as a function of energy density shows an increase, followed by a saturation and a final increase(?)

The T parameter depends also on beam energy

# T as a function of Particle Mass

Determining T parameter by fitting  
 $d\sigma_{\text{part}}/dM_T$  distributions with  $M_T^{3/2} \exp(-M_T/T)$

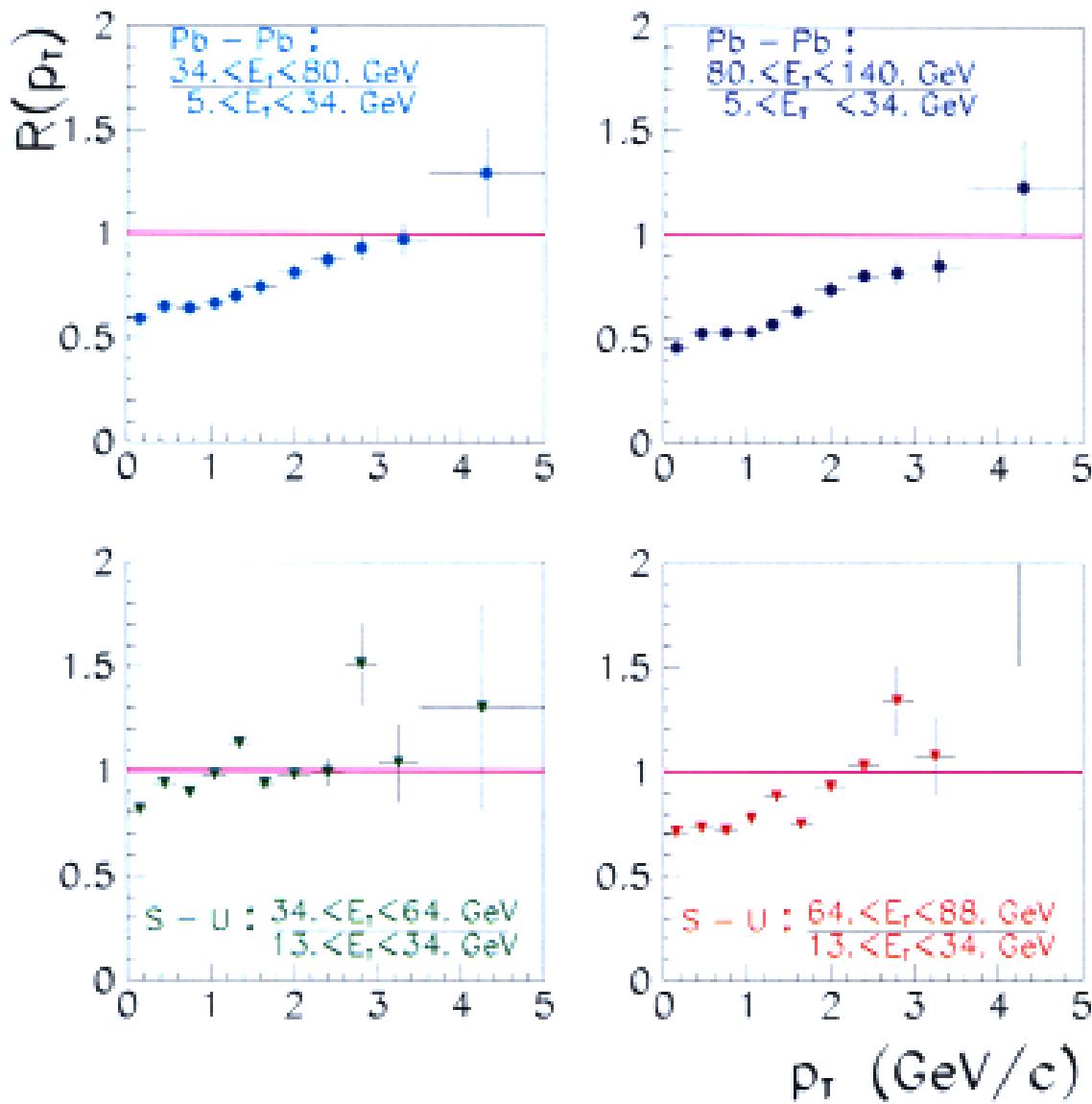


The rise of T with Particle Mass is smoother than the expected

## Ratio $R(p_T)$

$R(p_T)$  is the ratio of  $\psi$   $p_T$  distributions for a given  $E_T$  region with respect to the lowest  $E_T$  region, normalized to the ratio of the corresponding  $DY$  events:

$$R(p_T) \equiv \frac{\frac{dN_\psi}{dp_T} / N_{DY} \quad (\text{high } E_T)}{\frac{dN_\psi}{dp_T} / N_{DY} \quad (\text{low } E_T)}$$



In Pb-Pb central collisions  $R(p_T)$  seems to saturate at high  $p_T$